TRANSIMS TRAVELOGUE

November 1995

TRANSIMS TRAVELOGUE describes current activities within the TRANSIMS project.

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WHAT IS TRANSIMS?

The TRansportation ANalysis and SIMulation System (TRANSIMS) is one part of the multi-track Travel Model Improvement Program sponsored by the U.S. Department of Transportation, the Environmental Protection Agency, and the Department of Energy. The TRANSIMS project has been identified as a major effort to develop new, integrated transportation and air quality forecasting procedures necessary to satisfy the Intermodal Surface Transportation Efficiency Act and the Clean Air Act and its amendments.

TRANSIMS is a set of integrated analytical and simulation models and supporting data bases whose development is led by the Los Alamos National Laboratory. The TRANSIMS methods deal with individual behavioral units and proceed through several steps to estimate travel. TRANSIMS predicts trips for individual households, residents and vehicles rather than for zonal aggregations of households. TRANSIMS also predicts the movement of individual loads of freight. A regional microsimulation executes the generated trips on the transportation network, modeling the individual vehicle interactions and predicting the transportation system performance. Motor vehicle emissions are estimated using traffic information produced by TRANSIMS. TRANSIMS major advantage for air quality analysis is the detail it provides regarding motor vehicle operation.

We will develop an interim operational capability (IOC) for each major TRANSIMS component. When the IOC is ready, we will complete a specific case study to confirm the IOC features, applicability, and readiness. We will complete the specific case study with the collaboration of a selected MPO staff. This approach should provide timely interaction and feedback from the TRANSIMS user community and more interim products, capabilities, and applications.

The Traffic Microsimulation is emphasized in the first IOC, with the goal of having it ready for testing early in 1996. As this IOC is developed, we are working with the selected MPO, North Central Texas Council of Governments (NCTCOG) (Dallas-Fort Worth), to identify studies that the IOC should support.

CELLULAR AUTOMATA RESEARCH

We examined improvements to our cellular automata (CA) methods for traffic simulation that would yield fundamental diagrams (flow vs density) more comparable to real world data while still achieving rapid computational speeds. These techniques include calculations that cycle through the vehicle objects, as is done for continuous spatial methods, instead of cycling through the grid cells as is normally done for CA methods. Because the number of vehicle objects is considerably less than the number of grid cells, the computations should be much faster, depending on the CA rule complexity.

We also examined the CA vehicle state transition rules in terms of the theoretical simulation concepts we developed earlier and feedback control systems theory. The rules interacting with the simulator procedures produce emergent local behaviors that can be interpreted formally as traditional feedback control systems theory with noise introduced at various points in the feedback control system. By tracking the vehicle states (velocities and gaps between vehicles) and their transitions, we have recast the CA methods into control theory equivalents. The vehicle controllers in interaction offer the prospect for making explicit the control rule transitions that are occurring implicitly in the CA. That would allow explicit identification of the detailed driver "behavioral models" that occur in the CA, but are not obvious.

SUBSYSTEM DEVELOPMENT

In the June 1995 TRANSIMS TRAVELOGUE we described the overall TRANSIMS software framework and architecture. Since then we have implemented several subsystem designs.

The database subsystem now supports all major functions needed for the IOC, including support for writing to the database and for schema changes. We tested the subsystem with automated test scripts that allow for future regression testing. The testing verifies that all functions work as specified and that the subsystem handles exceptional conditions gracefully. This mature subsystem will

require few additional functions. We have reviewed, documented, and tested this subsystem.

The Oracle database performs well and provides common access to TRANSIMS data via either the C++ programming language or the ArcView Avenue programming language. The database subsystem will work without modification with other databases such as Sybase.

We completed the initial design of the network representation subsystem. We received input from members of the transportation planning and engineering community to assure a comprehensive, understandable representation. We implemented and tested major portions (nodes, links, unsignalized intersections, signalized intersections, parking) of the subsystem. We developed auxiliary tools for checking the network consistency, for lane connectivity generation when information is missing, and for regression testing. In subsequent iterations we added enhanced control over the creation and distribution of network objects on multiple processors and optional data items to support the Interim Planner and CA microsimulation. The current network representation describes and models the fundamental features of road networks; future enhancements will focus on functionality needed specifically for the IOC and the Dallas-Fort Worth case study. We have reviewed, documented, and tested this subsystem.

We designed and implemented the plan subsystem. This representation records a traveler's route from one place to another. The plan incorporates the notions of activities and modes. People travel from one place to another to engage in an activity at their destination. The transportation modes include the particular vehicle in which the traveler is riding, so there is a mode change when a person changes vehicles for ride sharing.

A plan is a list of trips that take a traveler from one activity to another. A trip is a list of uni-modal legs. This allows the traveler to change vehicles and transportation modes on the way from one activity to another. Finally, a uni-modal leg is a list of network links that compose the traveler's route.

We implemented the establishment subsystem. An establishment is any place where people stop to engage in an activity. It could be a house, a business, a school, or a recreational area. An establishment may have a list of activities to be accomplished by someone who is there. For example, if an establishment is a home, the establishment's activities might include going to the grocery store. The travelers in an establishment also have their own private list of activities to be accomplished.

For the IOC, available establishments include family household, non-family household, group quarters, and commercial. The establishment is identified with a specific location relative to the transportation network model. We tested the subsystem with automated test scripts that allow for future regression testing. The testing involves verifying that all functions work as specified and that the subsystem gracefully handles exceptional conditions.

We implemented a preliminary version of the activity subsystem. People travel from one establishment (or location) to another to engage in an activity. Currently, the two available activity types are distinguished by their time characteristics. In the first, an arrival time interval and a departure time interval are given. For example, a traveler might arrive at work between 8:00 and 8:15 and depart between 4:30 and 5:00. In the second, an arrival time interval and a duration interval are given. For example, a traveler might arrive at the store anytime between 10:00 AM and 4:00 PM, and shop for 30 to 40 minutes. Each activity is associated with an establishment and, hence, to the network model.

We designed the simulation output subsystem and implemented its basic functions. We began the design process with background research on parallel I/O systems. These included the PIOUS system, which integrates well with PVM, the software used to distribute the TRANSIMS processing among computer work stations. The simulation output subsystem design and architecture focuses on long-term flexibility and usability and minimizes the communication burden on the simulation network. The initial implementation collects vehicle trajectory data for use in animation and measures-of-effectiveness (MOEs) calculations. We successfully integrated the output subsystem with the distributed CA Microsimulation. Future enhancements of this subsystem will collect summarized data and improve preprocessing and indexing of data. We have reviewed, documented, and tested this subsystem.

We are developing the input editor system in conjunction with work on the editing of the network data provided by NCTCOG. The editor functions support the retrieval and storage of data from the Oracle database, validate network data, and provide some visualizing and editing of traffic networks. We will review this system's design and implementation as the development progresses.

IOC MICROSIMULATION

We added driver logic to the microsimulation that allows vehicles to maneuver in multi-lane traffic,

follow plans, and navigate signalized intersections. We are continuing to test the subsystem integration and driver logic.

We integrated the database, network, and simulation output subsystems with the microsimulation. Integration with the network and database subsystems allowed us to perform simulation runs on sections of the NCTCOG network. Integration of the simulation output subsystem allows vehicle tracking at specified intervals as they move through the transportation network. We acquired profiling tools that help optimize the performance of CA microsimulation, parallel toolbox, and other TRANSIMS systems.

CONFIGURATION MANAGEMENT

All TRANSIMS software is under configuration management. We developed a general configuration management plan and selected a configuration management system, ClearCase from Atria Software, Inc. We developed ClearCase versioned object bases (configured collections of software files) for the research team microsimulation, for the network subsystem, for the database subsystem, for the planner, for the analyst toolbox, and for vehicle software. Our approach to configuration management is to observe software development practices within TRANSIMS, derive consensus on the best practices, and enhance those practices with version and configuration control.

CASE STUDY DEFINITION

The case study associated with the first IOC is designed to confirm the IOC features, applicability, and readiness. The study goals are two-fold: first, to demonstrate TRANSIMS on a prototype transportation problem, and second, to examine the results' sensitivities to TRANSIMS assumptions and parameters. In concert with NCTCOG we have identified a 16-square-mile region of interest (ROI) along the Lyndon B. Johnson Freeway (I-635) to focus the microsimulation analysis. From another viewpoint, the study encompasses the whole Dallas-Ft. Worth region because we have generated ten complete synthetic populations and will generate time-of-day trip plans for each household in each population. We will truncate these trip plans to the ROI for the microsimulation study.

The prototype analysis problem will examine high-occupancy vehicle lanes as an option for reducing traffic congestion. Study cases include: the existing four-lane freeway, an upgraded six-lane freeway, a six-lane freeway with two lanes designated as HOV, and the existing freeway and a barrier-separated two-HOV-lane system. Though the analysis problem focuses on the freeway system changes, we will analyze the total ROI roadway network.

Thus, we will measure how the freeway system modifications affect traffic on the arterials, ramps, frontage roads, collector streets, and local streets as well as on the freeway.

Probable TRANSIMS parameters and assumptions to be studied include: network representation such as local street detail, ROI boundary conditions and distances from selected MOE roadway segments, initial conditions, driver logic and representation, trip plans, populations, etc. The number of studies is considerable so we will have to be selective in deciding which variables to include.

We are designing the study as a systems analysis in which we impose demand on the transportation system and evaluate the system's response by various MOEs. We abstract sets of demand from the synthetic demand, that is, from specific time periods in the population trip plans. Each abstracted demand is characterized by a fixed rate of vehicles entering the system and by the traffic patterns within the system. Correlated relationships, for example, congestion thresholds, between the system response and the demand characteristics can be identified with such systems analysis designs. Though the case study is designed this way, the microsimulation IOC itself will permit studies in which the system is loaded with the synthetic demand on a second-by-second basis throughout a specified time period, for example, a 24-hour period or a morning peak period.

The TRANSIMS IOC will produce vehicle position second-by-second for selected roadway segments. MOEs, such as average speed, person/vehicle time of travel, person/vehicle miles of travel, person/vehicle time of signal delay, person/vehicle time of congestion delay, variances in these measures, etc. will be derived from this output. In addition, vehicle trajectories as well as traffic flow and the previous MOEs as functions of traffic density will be plotted and compared for the various cases. We also will provide animation of the vehicle movements both for analysis and for evaluating the IOC's proper functioning.

FOUR-STEP PROCESS DATA

Preparations for the IOC and its associated case study are giving us a taste of what to expect for TRANSIMS data availability. This first IOC relies on currently available and augmented four-step process data, particularly census data, production/attraction (PA) tables, origin/destination (OD) matrices, the transportation network data, and other information. We have received these basic four-step process data from NCTCOG for the Dallas-Fort Worth region.

TRANSIMS has an activity-based structure. We generate all travel plans from the activities assigned to households and individuals. However, a complete activity model is not necessary. In TRANSIMS trips are the means to arrive at an activity location. For example the first activity of the day may be at home, while the second is a work activity at a different location. A trip between these two locations is the natural consequence of the two activities. This suggests that even with the TRANSIMS activity-based approach, the four-step process information can produce pseudo activities to generate trips. For example, the entries in the OD matrices or the PA tables each can be assigned two activities that will result in one trip between the two zones.

On the other hand, the network representation in the four-step process permits assumptions that are questionable within the TRANSIMS framework. For instance, in the four-step process, a collapsed network can intersect roadway segments artificially at a node and capture the overall traffic volumes adequately even though the segments may not intersect in reality. Intersections may be modeled as traffic delays. In TRANSIMS the transportation network must be represented realistically for the vehicular interactions to produce reasonable traffic behavior. However, one questions what resolution is necessary, and presumably the answer depends on the issue being studied.

For the case study we requested local street and additional road network data for the major intersections within the ROI. We participated in a meeting at NCTCOG with consultants and traffic engineers from local municipalities to discuss the data collection for the TRANSIMS network representation for the study. We were surprised to learn that the data is not readily available, though in subsequent analyses and processing of the additional road network data provided by NCTCOG, we found how painstaking it is to work with such copious data. We are working with NCTCOG to automate the network representation process. One study objective is to assess the required network detail.

FURTHER INFORMATION

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